Report

3rd Meeting of the Electron-Ion-Collider Advisory Committee (EICAC)
April 9, 2011

EXECUTIVE SUMMARY

The third meeting of the Electron-Ion-Collider Advisory Committee (EICAC) was held on April 9, 2011 at the Thomas Jefferson National Accelerator Facility (JLab) in Newport News. The meeting had been organized by Brookhaven National Laboratory (BNL) and preceded a workshop at Newport News on deep-inelastic scattering (DIS 2011) that immediately followed the EICAC meeting. This provided an added opportunity for the Committee to interact with parts of the EIC research community. The Committee wants to thank both, BNL and JLab for their kind hospitality.

The purpose of this EICAC meeting, as of the previous ones, comes from the original charge to EICAC: To periodically review EIC progress and provide feedback and advice on project development. This included at this third meeting also an assessment of recent developments towards the EIC in response to questions and suggestions from the two earlier meetings of EICAC.

Unfortunately, because of time constraints and the subsequent workshop the EICAC meeting was limited to a single day. Given that a number of substantial activities towards the EIC have taken place over the past year, including a 6-week sequence of EIC related workshops at the Institute of Nuclear Theory (INT) at Seattle, significant R&D and design activities at BNL and JLab on the respective EIC facility concepts, and conceptual designs and R&D towards detectors, the one-day meeting was largely needed for the presentations on these recent developments. This provided for limited, and in many respects insufficient, time for discussions and Committee deliberations. The meeting was largely a report to EICAC rather than a Committee review.

In view of the extensive proceedings of the EIC INT Workshop that were reported to be in preparation and tentatively available to the Committee within a time frame acceptable for the present Report, the Committee considered this a workable compromise. Unfortunately the INT proceedings have not yet become available. The Committee understands that, given the length and breadth of the INT workshop series the production of the proceedings is not a trivial matter; particularly in view of the goal to present a crisp and convincing science case.

Given this somewhat tentative situation though, the Committee wants to focus on four brief recommendations and a suggestion with regard to the EIC science: first to pursue the careful quantification of impact and discovery potential of the EIC for the physics areas discussed; second, to develop the previously recommended matrix with clear and well-defined science goals versus required EIC performance characteristics; third, to analyze in

some detail to what extent which of the goals may or may not be realistically (and quantitatively) reachable by utilizing existing facilities and/or their upgrades (LHC etc); fourth, in order to study the physics performance and to inform the above discussion, to start a significant effort in first order (parameterized) detector simulations. The Committee finally suggests to have, in the not too distant future, a more extended (perhaps 2-day) review of the EIC status as it will emerge from the INT EIC Proceedings (and other developments), including more details about next steps and quantification of EIC parameters as they are established therein.

From the overview presentations on the status of the science discussions which summarized the results from recent workshops and in particular the INT series on EIC physics, the Committee concluded that significant progress, in particular on the theory side, has been made in consolidating key areas and some potential golden experiments have been addressed: Spin, flavor and 3D structure of the nucleon, saturation and high-density gluonic matter, and recent studies into electro-weak physics opportunities at the EIC. As a general theme, the new capabilities of the EIC in kinematical range and luminosity will provide unique and important physics opportunities for small Bjorken x and for key areas of non-perturbative QCD and saturation. It was also clear that further detailed quantitative studies and simulations are necessary to delineate the quantitative impact on the science.

With regard to the accelerator facilities the EICAC found that considerable work has been done by both JLab and BNL on the EIC facility designs. JLab has made significant advances in the design of the hadron injector and storage ring, and BNL presented an alternative design to MeRHIC which avoids conventional construction outside of the RHIC tunnel. Again, the time for presentations and discussions was rather limited and essentially only broad overviews could be presented from each laboratory.

In summary, both laboratories have done excellent work in moving forward on facility design and R&D issues. Performance deliverables in terms of energies and luminosities have converged. However, we note that both machine designs remain very challenging, and considerable work remains to identify and address project technical risks. We continue to encourage the collaboration to follow through with the recommendation from the last review including the above mentioned matrix, and a clear delineation of what is being considered as part of the proposed EIC (project) versus what is being considered as upgrade performance. We recommend that in future presentations each facility clarifies what is being considered as part of their baseline proposal, and separately what the ultimate upgrade performance might be.

It is furthermore recommended to perform start-to-end simulation of the BNL ERL design and to have it reviewed by ERL beam dynamics experts. This effort must consider losses, beam stability and energy recovery. Regarding the coherent electron cooling (CeC) effort we suggest that BNL develop a fall-back electron cooling design. In general, the Committee recommends to conduct technical design reviews and cost estimates for both proposed facilities with enough similarity so that credible conclusions can be drawn on technical realization, cost and schedule; perhaps this could be done by establishing a joint technical review committee as discussed in the main section of this Report.

The Committee heard an overview presentation about detector developments. Good progress has been made on the detector – machine interface, and in defining the physics case such that benchmark processes can now be selected for detector parameter optimizations.

The study of the physics performance using first order (parameterized) detector simulations has barely started – thus the progress since the last EICAC meeting is disappointing. The Committee reemphasizes its previous recommendation on the importance and the urgency of simulation work to understand the relation between detector performance and quality of physics results, in order to better understand the trade-off between detector resolutions and acceptances on the one hand, and luminosity, polarization and beam energies on the other. This work is also important to better understand the specific detector R&D efforts required for experiments at the EIC. It also is necessary to establish the number of interaction regions in the collider and the corresponding, perhaps complementary detector designs. It appears obvious that both laboratories and the EIC-community will have to strengthen the effort to achieve necessary progress.

The EICAC is pleased to hear that a call for proposal for EIC related detector R&D has been issued, and a corresponding advisory committee has been appointed.

The Committee discussed aspects of collaboration and research community, as well as unavoidable institutional aspects in the main body of the Report. It has no specific recommendation other than that these need to be openly addressed. In more general terms, the Committee finds that the EIC collaboration will need to speak with a single voice to the rest of the nuclear physics community in order to generate support for the project in the next Long Range Plan.

While the Committee agreed on what is outlined in this Executive Summary, individual members expressed some additional concerns. Some felt that most of the science topics warrant a more timely effort. The timelines presented for the projects at the meeting, so in particular some foreign members of EICAC, are seen as rather late for the questions to be answered. The constraints from the US funding perspective and from the process that underlies the past, rather successful nuclear physics planning process in the US are realized and understood. Nevertheless, there was desire to express encouragement to the management of the laboratories involved to accelerate the process which, in these members' opinion, will also enhance international interest in EIC participation.

DETAILED REPORT

The Science

Spin, flavor and 3D structure of the nucleon

The **spin and flavor structure** of the nucleon remains to be one of the outstanding problems in nucleon structure physics. The polarized structure function g_1 has been measured mostly in fixed target experiments and has very limited information for $x < 0.05$. Current polarized parton distributions, particularly the gluon helicity distribution, Δg, has a very large uncertainty at small x. Although jet production at polarized RHIC has narrowed down the integral of the gluon helicity considerably, large uncertainty remains in the contribution from small x. It has been well-recognized that an EIC, already at a first stage allows one to access the polarized spin structure function down to an x-value of a few times 10^{-4}. A subsequent upgrade will allow probing information approaching the 10^{-5} range.

Semi-inclusive Deep Inelastic Scattering (DIS) is an excellent tool to probe the flavor structure of the nucleon. The approach has been sharpened considerably through the fixed target experiments by the HERMES collaboration at HERA and the COMPASS collaboration at CERN. Charged kaon production has the ability to future constrain the polarized and unpolarized strange quark distributions significantly, particularly in the small-x region where the uncertainty is very large. The expected quantitative impact and improvement on the current knowledge is yet to be worked out.

Weak interaction processes including neutral and charged current exchanges add additional power to probe the spin-independent and spin-dependent parton distributions. HERA has already demonstrated how this can be done. High luminosity at EIC has a distinguished capability. Detailed simulations on the reach of the parton distributions are yet to be carried out.

Generalized Parton Distributions (GPDs) provide information on parton distributions in coordinate space and, in a more restricted sense, the parton density in the 2D impact parameter space. This information is complementary to the linear momentum distribution in x and provides a tomographic picture of the nucleon. At small x, the sea quark and gluon distributions in the transverse directions are very valuable for understanding the non-perturbative QCD dynamics. Combination of parton linear momentum and coordinate space position allows reconstruction of the parton orbital angular momentum in a transversely polarized nucleon, as exemplified by the GPD angular momentum sum rule.

GPDs can be probed through deeply-virtual exclusive processes in which a DIS virtual photon scatters with a nucleon, producing a recoiling nucleon plus a high-energy particle of zero baryon number. Deeply Virtual Compton Scattering (DVCS) has a real photon in the final state. Other processes come with production of J/ψ and φ meson, ρ mesons, pseudo-scalar mesons such as pions and kaons, etc. The experimental study of GPDs has just begun,

and none of the existing facilities so far has been ideal for this. The Jefferson Lab 12 GeV upgrade has the promise of providing considerable knowledge about GPDs.

As shown in Vadim Guzey's talk, an EIC with high luminosity and a wide range of kinematics variables and polarization is an ideal place for studying the novel distributions and has the potential for leading to a program of "golden experiments". Preliminary simulations have been made with DVCS and other processes for absolute cross sections and spin asymmetries as functions of various kinematic variables, showing that an EIC with high luminosity provides high quality data to extract GPDs. However, analysis on the uncertainty of extracted GPDs has yet to be done systematically. This is a particularly relevant exercise because GPDs depend on multiple variables, and some observables are completely blind to the functional dependence of some of them. In certain cases, only a large Q^2 coverage may overcome the problem of degeneracy. A reliable determination of GPDs may only be achieved by fitting data using flexible-enough parameterization of GPDs and exploiting the complementary constraint from lattice QCD calculations as well. A "killer-plot" showing the accuracy of the GPD extractions from EIC must be worked out in the near future.

The parton's **Transverse-Momentum Dependent Distributions (TMDs)** provide valuable information on the non-perturbative QCD dynamics in the nucleon and can be probed through various hard processes including DIS, e^+e^- annihilation and Drell-Yan scattering. Because the color flow in different processes is different, TMDs do not have as wide an universality as the integrated parton distributions do. This fact poses both a challenge as well as an opportunity.

An EIC with polarized beams and semi-inclusive hadron detection allows probing many different TMDs with interesting parton momentum and spin and nucleon spin correlation effects, as presented in Hyan Gao's presentation. Through SIDIS experiments at DESY, CERN and JLab, much experience has been gained in studying various TMDs in the experiment. However, a number of outstanding theoretical and experimental questions have to be addressed before this becomes a "golden experiment" program at the EIC:

- In theory, one must demonstrate why the TMDs are critical to understand the internal structure of the nucleon. In particular, one has to see what interesting and valuable information one can learn about the partons through these observables. This is closely related to how to perform solid theoretical calculations of the different versions of TMDs and their spin and flavor properties, and making qualitative and quantitative comparisons between theory and experiment. In some cases, factorization theorems involving TMDs have not yet been solidly established.

- In data analysis, a solid connection between the transverse momenta of the hadron and parton must be established through Monte Carlo simulations, as there are multiple sources of transverse momentum, seen through factorization theorems. Particularly the role of soft-gluon radiation becomes a more important issue at collider energies.

- One has to establish what additional critical information can be learned with an EIC as compared to the current programs, such as the one for the Jefferson Lab 12 GeV upgrade.

Saturation and High Density Gluonic Matter

As part of his overview of the INT program Markus Diehl summarized the highlights of the small-x physics that could be done at an EIC. A more detailed discussion of some of these topics was then given by Cyrille Marquet. Both speakers summarized the current status of small-x and high gluon density physics and emphasized new or improved measurements that the EIC would furnish.

An electron-proton program has recently been carried out at HERA but was closed down in the summer of 2007. The HERA program was very interesting and produced many impressive results. Specifically, HERA had a maximum electron-proton center-of-mass energy of 320GeV and a luminosity of a few 10^{31} $cm^{-2}s^{-1}$. The structure function F_2 and the parton distribution functions, including the one of the gluons, were measured with high precision down to x-values of a few 10^{-5}. However, HERA did not have nuclear beams; and the detectors were designed primarily with high Q^2 in mind, such that they were not optimal for small-x physics. Direct measurements of F_L at 3 proton energies had limited accuracy, and while the results were compatible with saturation effects at high gluon density they could not be proven.

Detectors designed with the small-x physics in mind would allow for significant improvements and kinematic coverage in the small-x and small-Q^2 regime. There is a chance to realize this at the EIC. Also, more flexibility in setting beam energies and higher luminosities will allow significantly better FL measurements as well as much improved measurements of exclusive processes. Perhaps most importantly, adding nuclei will add a completely new angle on small-x physics.

There is currently an important small-x program being carried out at RHIC at BNL using d-Au collisions and one can expect a strong proton-nucleus program from the LHC at CERN in the not too distant future. While electron-nucleus induced reactions are much cleaner and more precise than proton-nucleus collisions the exceptionally high energy of the LHC makes it a formidable competitor. It would be nice to have a more complete and detailed study of what can be obtained from the EIC which cannot be inferred from a long running proton-nucleus program at the LHC.

Finally, if CERN were to build the LHeC it would be the ultimate small-x machine. However, it is perhaps premature to compare the EIC to a machine which probably has a small likelihood of becoming real.

Markus Diehl listed the measurement of F_L for heavy nuclei as a "golden measurement". Non-linear QCD effects (saturation) are expected to be most visible in F_L which is especially sensitive to gluons. A breakdown in ordinary QCD evolution (DGLAP evolution) would be interesting in its own right, and the nature of the evolution which F_L follows should directly test the expected form of evolution in the presence of a dense gluon distribution.

Forward di-hadron and di-jet events at RHIC have so far given the sharpest signal for parton saturation. EIC produced di-hadron and di-jet events would be much cleaner because

the incoming (virtual) photon momentum would be known precisely while at RHIC there is a spectrum of energies for the parton initiating the reaction. In addition at RHIC, or at the LHC, spectators from the incident deuteron, or proton, make the final state more complex than the final state of a photon induced process. On the other hand, the exceptional energy of the LHC is a great benefit in studying di-jet events making it not so clear how much will be left for the EIC. A more detailed comparison of di-hadron and di-jet physics at the LHC and the EIC is important.

Diffractive vector meson production has been extensively studied at HERA and interesting, if rough, results on the spatial distribution of gluons in the proton as well as a crude determination of the impact parameter dependence of dipole cross section emerged. As discussed both by Markus Diehl and Cyrille Marquet this program could be done very effectively at the EIC both on protons and on nuclei. For saturation issues the impact parameter dependence of dipole cross sections for large nuclei would be especially interesting.

It has long been recognized that electron-nucleus collisions are the ideal setting to study parton evolution and hadron formation in cold nuclear matter. By varying the electron beam energy and the atomic number one can regulate how much evolution occurs in the nucleus and how much occurs outside the nucleus. The amount of energy loss and the transverse momentum broadening of the produced high energy hadrons or jets could be compared to QCD calculation that are now being developed mainly for use in the hot matter produced in high energy heavy ion collisions.

Electroweak Physics at the EIC

The EIC project is mainly driven by QCD and nuclear physics questions. However, electroweak physics provides a complementary program with interesting possibilities due to the high luminosities and polarization expected at the EIC. The topics singled out in the INT workshop were the measurement of the weak mixing angle and the independent access to helicity distributions using charged current (W exchange) interactions. Examples of possible measurements were given which appear promising, albeit only with statistical uncertainties evaluated so far. These encouraging results have led to LDRD funds being allocated to add manpower for additional studies into the physics potential at an EIC.

The EICAC considers this a positive development, and encourages further evaluation of the physics potential of an EIC for the electroweak sector of the Standard Model. In particular, it will be important to determine to what extent the physics reach will be determined by machine limitations (energy, luminosity, polarization) and whether special detector considerations are needed.

The EIC Accelerator Facility

Considerable work has been done by both JLab and BNL on the EIC facility designs. JLab has made significant advances in the design of the hadron injector and storage ring, and BNL presented an alternative design to MeRHIC which avoids conventional construction

outside of the RHIC tunnel. Unfortunately the time for presentations and discussions was rather limited; only overview presentations from each laboratory were possible.

Jefferson Lab Facility: JLab now has a facility design which includes a hadron injector accelerating protons to 3 GeV (we only quote the proton energies in this brief summary), a hadron booster (referred to in the design as the large booster) constructed of warm magnets with a top energy of 20 GeV, and a hadron collider using SC magnets with a design energy of 60 GeV. Electrons are provided to the electron collider ring from CEBAF with available energies from 3 GeV to 11 GeV. The design point in the tables provided 5 GeV electrons. The facility utilizes the figure eight layout with three interaction regions (IPs).

The luminosities shown at the design points are in the range of 5.6 to 14.2 x 10^{33} $cm^{-2}s^{-1}$. These are achieved by relatively low charges per bunch, high collision rates (750 MHz; all buckets are filled in both colliders), short bunches, and very small β^* values.

Jefferson Lab has begun design work on other issues such as polarization of both electrons and protons, IR region design, crab crossing techniques, synchronization, and cooling of the proton/ion beam. The cooling scheme chosen by JLab is traditional electron cooling (as opposed to coherent electron cooling being pursued by BNL) although we note that traditional electron cooling has never been utilized at the beam energies proposed by JLab, leading to the need for R&D.

Brookhaven Facility: The BNL presentation showed that the proposed facility is now the eRHIC design that we were shown at the last EICAC meeting. It is claimed to be less expensive than MeRHIC. Furthermore, the luminosity performance of eRHIC has been improved from 2.8 x 10^{33} $cm^{-2}s^{-1}$ shown at the last EICAC to 14.6 x 10^{33} $cm^{-2}s^{-1}$ at the present meeting. This gain is the result of improvements in superconducting quadrupole technology to reduce the β^* from 25cm to 5cm, and the inclusion of crab cavities. Other parameters remain the same as from the presentation in 2009 (charge per bunch, collision frequencies and beam energies).

BNL has focused on R&D aspects of the design, and has appropriately addressed the high current polarized gun and laser system. This is encouraging and the progress is to be commended. Progress has also been made in moving forward on the coherent electron cooling (CeC) proof of principle experiment, and on beam-beam effects. The committee would like to see further progress on high energy ERL developments, and on some variant of start-to-end simulations of the ERL that would verify the feasibility of the design.

General Technical Considerations: There are several areas of concern regarding collider performance for both concepts.

Beam dynamics in MEIC:

- Space charge effects are expected to be very strong – even for 60GeV proton operation, the Laslett tune shift is estimated to be dQ_{sc}=0.07 that is already beyond anything ever achieved for DC mode operation (though for pulsed mode fast cycling

operation the tune shifts of about 0.4 are reality), therefore, high beam losses, emittance blowups and lifetime reduction can limit the machine performance. For comparison, the highest tune spread parameter ever achieved in hadron colliders (Tevatron) is about 0.028. Electron cooling can provide an additional stabilization factor only if it is very fast (faster than SC instability) and if it affects coherent modes as well – the latter needs to be confirmed in at least numerical studies. If the machine will operate at lower energy, say, at 20GeV, then the tune shift will be even higher ~0.6 and long term stable operation does not seem feasible. The space-charge effects – which scale as $1/\text{energy}^2$ - will be significantly stronger in the pre-booster, another machine where particles are expected to circulate for a long time to be cooled, but with energy of only few GeV or less. Operation for other species, ions with higher charge, may be compromised by the space-charge effects as well.

- Despite a relatively small individual proton bunch population (e.g., about 10 times lower than in Fermilab's Booster and Main Injector), the electron cloud effects are a serious concern because of the very small bunch-to-bunch separation (14 times smaller than in the 53 MHz Fermilab machines) and significantly smaller rms bunch length.
- Very small values of beta-functions at IPs - 2cm or even 0.8 cm – are of particular concern as corresponding optics solution(s) should provide not only first, but also higher order compensation of chromatic effects, otherwise resulting in insufficient dynamic aperture of the machine (both transversely and in dp/p). Though the first steps were made in that direction, no convincing evidence was presented for the dynamic aperture. Correction of chromatic effects in the presence of strong space-charge forces looks extremely challenging and also requires very careful study.
- Production of the required high-current highly polarized ions (^{3}He and Li) and electrons will probably require development of sources beyond current state-of-the art.

Beam dynamics in eRHIC:

- Disruption of the 20-30GeV electron beam due to collisions with protons is expected to be as severe as in linear e^+e^- colliders or worse (e.g., ILC's $\xi=D/2\pi \sim 3$). But contrary to the linear colliders where the spent beam goes to a dump, in the proposed eRHIC scheme the beam of electrons has to be decelerated in a number of turns in the same multi-turn magnetic structure as used for acceleration. It is not clear whether an electron beam being strongly distorted by the highly nonlinear force of the proton space charge can be matched to the return path optics, and thus, beam losses can be satisfactorily controlled.
- Correspondingly, the aperture of the return magnets (several dozens of kilometers of them) may need to be optimized (increased) and efficiency of deceleration and energy recovery reconsidered.
- A very small beta-function at the RHIC IP - about 5cm - poses serious concerns about the dynamic aperture of the machine (both transversely and in dp/p).
- Production of the required high current highly polarized electrons requires development beyond current state-of-the-art.

Ion Beam Cooling:

Both proposals require electron cooling at the collision energy in order to achieve the design luminosity. The BNL presentation showed a facility concept based on a coherent electron cooling (CeC) system. The reliance on an untested cooling method presents a technical risk not fully assessed in the presentation. The committee strongly endorses the proof-of-principle experiment on CeC and, because of the risk, suggests that as a fall-back position a design with conventional electron cooling system be also developed.

The JLab presentation is based on a conventional electron cooling system. Although the principles of electron cooling are well understood, the proposed system still requires several elements at or beyond present state-of-the-art. The role of electron cooling at the collision energy is to counteract the heating due to the intra-beam scattering (IBS). The IBS growth times presented are of the order of 60 seconds (at 60 GeV). The estimated electron cooling time is of order of 8 sec. This cooling time estimate seems to be quite optimistic. The electron cooling time at Fermilab with 8 GeV antiprotons is of order of minutes. Since the cooling time increases with energy (at least linearly), the estimated cooling time of 8 sec requires some careful analysis of assumptions and simulations. Such an analysis was not presented by JLab (nor by BNL). Specifically, from experiments at FNAL it is known that the cooling time is very sensitive to both the electron and the ion beam transverse angles in the cooling section. This sensitivity is so high that it may result in an increase of the cooling time by a factor of 8 if the angular spread is doubled. From this point of view, a multi-pass circulator scheme may be of higher risk because in such a scheme it is much harder to control the electron beam quality on multiple passes.

Accelerator Aspects and LRP:

It is not the intent of the EIC collaboration to do a down-select prior to the LRP, and it is not the intent of the EICAC to encourage it. However, both facilities indicated in their presentations that they will perform a design review and cost estimate over the next year (BNL: Design review in summer 2011, and cost estimate in fall 2011; JLab: Design review and cost estimate in December 2011). It seems reasonable to encourage an approach which brings the same level of scrutiny and detailed assessment to both. The committee would like to suggest an approach in which the same expert group does the design reviews of both. The review team should include members from both BNL and JLab, but should have strong outside expert participation and be chaired by someone external. Likewise the cost estimates should be reviewed by the same team using the same approaches, particularly with respect to translating each facility's technical risk into contingency allocation.

It is inevitable that this appears to look like a selection process (which it is not); however the committee questions the utility of cost estimates if they are done using different, and perhaps difficult to discern criteria. They may be more misleading than helpful.

In summary, both laboratories have done excellent work in moving forward on facility design and R&D issues. Performance deliverables in terms of energies and luminosities have converged. However, we note that both machine designs remain very challenging, and considerable work remains to identify and address project technical risks. We continue to encourage the collaboration to follow through with the recommendation from the last review.

EICAC had made several suggestions. The first one was to develop a clear and well-defined matrix of science goals versus required accelerator performance parameters.

This has not yet been communicated to EICAC, and the Committee stresses that many of the technical risks could be eliminated or, at least greatly reduced if certain performance parameters are relaxed. However, we also recognize that the science goals need to inform these decisions, hence the importance of the above recommendation.

Further, the Committee found it difficult to assess what is being considered as part of the proposed EIC (project) versus what is being considered as upgrade performance. We recommend that in future presentations each facility clarifies what is being considered as part of their baseline proposal, distinct from what the ultimate upgrade performance might be.

Detector(s)

Due to the time constraints of a one day meeting, there has been insufficient time to present the work done on detectors. As most of this information will soon be available in the Proceedings of the INT-Workshop of last autumn, more detailed conclusions will be reached once this material is available to the EICAC. Thus only first and certainly incomplete conclusions will be presented here.

Concerning the physics case for an EIC, major progress has been achieved by a close collaboration between theorists and experimentalists. A number of benchmark processes can now be selected for the detector and machine parameter optimizations.

Good progress has been made in the topic of the detector – machine interface. The problems have been evaluated and first order solutions are under discussion.

In the presentations of the different physics cases the assumption concerning the detectors in terms of acceptance, resolutions and background did not become always clear. In many instances the assumptions (e.g. for the y-range for the F_2 and F_L measurement) appeared optimistic and possibly not justified. Nevertheless, the information provided for the different kinematic configurations have been very important to guide the detector principles. The EICAC is of the opinion, that the talks on the web should be updated, to provide the missing information on the assumptions under which the results presented were achieved.

The work on the study of the physics performance using first order (parameterized) detector simulations has barely started – thus the progress since the last EICAC meeting is disappointing. As pointed out in the minutes of the last EICAC meeting, we stress again the

importance and the urgency of "simulation work to understand the relation between detector performance and the quality of the physics results" in order to better understand "the trade-off between detector resolutions and acceptances on the one hand, and luminosity, polarization and beam energies on the other hand". This work is also important to better understand the specific detector R&D efforts required for experiments at the EIC. It appears obvious that both laboratories and the EIC-community will have to strengthen the effort in order to achieve the required progress.

The EIC is pleased to hear that a call for proposal for EIC related detector R&D has been issued, and a corresponding advisory committee has been appointed.

EIC Collaboration and Laboratory Aspects

The research community has invested a significant effort in developing the science case for the EIC, through formal and informal workshops, in particular the 6-week INT EIC Workshop last fall. A significant number of scientists were involved, and for significant periods of the workshop. Some members of EICAC attended portions of the INT workshop. The feeling was that the community worked hard for the 6 weeks. The closeout reflected the still ongoing discussions in the community. Scientific debate was continuing by leading theorists about what could or could not be learned. The conclusions were perceived as yet not quite crisp, but are expected to be brought out clearly in the Proceedings.

The community is now busy writing these conclusions about the physics and the realization of an EIC. There has been limited time to reflect and let things simmer and consolidate. On the other hand, the time scale for the EIC is long. Many individuals cannot afford to spend a considerable fraction of their time on something that won't be realized until mid-next decade. They remain in some confusion as a group about priorities, even though they have made progress towards making the machine performance parameters similar. The EICAC meeting was perhaps too soon for an interim conclusion. The community needs time to finish their Proceedings/White Paper and select the best of it to present. The Committee is optimistic that this is the way to view the present status and is supportive of the process. It recommends that the community complete this phase and then report back in the near term, perhaps around the end of the year.

The general time frame is also an obvious issue for laboratories involved in planning for the future facility. In their general institutional contexts the process may appear as too soon or alternatively as not soon enough. This is, of course, not unusual in the development of a major facility such as the EIC and often the rule rather than the exception. Whatever the constraints and the boundary conditions, the Committee commends the two laboratories presently involved in developing facility concepts on their collaborative approach and the close relationship to the research community(s).

Science Community and the Nuclear Physics Long Range Plan

The next phase of the process, as elaborated above, will be critical for the impact on the next Nuclear Physics Long Range Plan (LRP). Since the last EIC Advisory Committee meeting, the EIC community has been quite active in advancing all phases of the project, within the collaboration but also to some extent within the broader nuclear physics community. Through the INT Program, the community has engaged in a very important dialogue that begins to better define the science of an EIC. Some 'golden' experiments have emerged from this dialogue. This is a major step toward defining the EIC science goals. It will be particularly important to develop the perspectives that explain the importance of these golden experiments to a more general audience.

From the overview presentations that were given on the INT Program, it is expected that a strong science case can be put together for an EIC. The community must follow this through to develop a compelling White Paper that clearly articulates the need for an EIC. This White Paper should focus on the science first. It is quite possible that a 'green field' approach to an EIC would be necessary to cover all of the important science. This is surely not going to happen so eventually there must be a reconciliation of the science and the facility. To the extent possible, the science case needs to be used to help define the machine and detector parameters.

The EIC machine and detector concepts at JLab and RHIC are evolving rapidly. With the INT Program, the EIC collaboration should soon be in a position to delineate the important science questions to be addressed at a future EIC. It will then be possible to address how well the two different designs map onto these questions. It will be important to do this soon so that adjustments in design and detector parameters can be made to maximize the overlap of each design with the science.

Looking forward, the EIC collaboration will need to speak with a single voice to the rest of the NP community in order to generate support for the project. With two competing designs, this will be difficult but it seems absolutely necessary to move the effort forward.